THE LANZAROTE UNDERGROUND LABORATORY

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ABSTRACT

Since 1987 and as a past of the research project that is carrying out the Instituto de Astronomía y Geodesia of Madrid in Canary Islands, a geodynamic permanent station is working in Lanzarote Island, the most northerly and easterly of the main islands of Canarian Archipielago.

The station has two fundamental objetives: (a) to test different instruments developed in the context of the tide research and to apply them to other areas of earth research; and (b) to investigate the possible correlations of earth responses to tidal forces and other phenomena, such as crust stucture and thickness, volcanism, geothermic anomalies and heat flow, seismicity, mass displacements inside the crust, ocean and atmospheric tides, metereological influences, deformations, etc...

In this paper, we present the instrumentation working in the three modules of the Lanzarote Geodynamics Station actually, and the main results obtained so far.

INTRODUCTION

The study of the earth tides has been one of the main investigation lines of the Instituto de Astronomía y Geodesia (I.A.G.) since 1972, when these investigations started to be carried out. In this 18 years a great effort has been made, with a total of 21 stations for gravimetric tides almost completely covering the Iberian Peninsula, moving in an important way fordwards the resolution of the very many problems we outlined at the begining and some others which arose as a consecuence of the running of the investigations (F. Lambas et al., 1981; M. Orejana et al., 1983(a); M. Orejana et al., 1983(b); R. Vieira et al., 1986(a); R. Vieira et al., 1986(b); R. Vieira et al., 1986(c); R. Vieira et al., 1988(a); C. Toro et al., 1988; R. Vieira et al., 1988(b); C. Toro, 1989).

The collaboration with the group of scientists of the Consejo Superior de Investigaciones Científicas dedicated to the study of volcanism in the Canary Islands, in the geodesy specific fields, started in 1984, and as a consequence of this collaboration we are offered the opportunity to install a laboratory for a permanent geodynamic investigation in Lanzarote, more exactly at the nort of the island and inside of the volcanic tunnel of the *La Corona* volcano; a really spectacular tunnel with more than 6 km length from the volcano to the coast line which continues in the ocean, underwater, for at least two more kilometers.

From the very beginning we gave us scientific objetives coherent with our investigations and so absolutely clear that we can resume them in the following points (R. Vieira et al., 1989(a); R. Vieira et al., 1989(b); R. Vieira et al., 1989(c); R. Vieira et al., 1989(d)):

1.º Those objetives related with investigations on gravimetric and clinometric tides, mainly in those aspects in which and island with the characteristics of Lanzarote has a greater interest: study of the effects from oceanic origin, correlation of the earth tide with the earth shell thickness (shell in Lanzarote has a thickness of about 12 km (E. Banda et al., 1981; A.G. Camacho et al., 1990)) possible correlations between tidal parameters and the anomalies with thermal origin (in Lanzarote there are important geothermic anomalies, mainly in the area of the great eruption of the XVIII century, with places where the temperature reaches 600 °C at only 14 m depth); temporary variations and possible modulations on amplitude factors and phase of the tidal harmonics, validity or not of the Schwiderski charts in the area of Canary Islands, etc.

2.º Those aspects of geodynamic interest, consequence of the continuous auscultation with high accuracy instruments not only gravimetric ones but on inclination and deformation in general. These sensors have been developed to register phenomena of a very small magnitude, such as earth tides, and being installed in a place like Lanzarote, wich can offer us information of a great interest from the volcanic point of view and its associated seismicity offers now a days a moderated activity, but a future potential totally unexpected. For this reason, we inted this laboraty to be a place to test instruments developed for different aplications which adapted, in every case, to the conditions of geodynamic activity of the area would provide us with an information about such activity additional to the one obtained through the usual methods.

Obviously, it is a geodynamic laboratory opened to the international collaboration, as it can be seen from the instruments installed as a consequence of the collaboration with the European Center for Geodynamic and Seismology (E.C.G.S) from Luxemburg and the Observatoire Royale de Belgique (O.R.B.).

DESCRIPTION OF THE STATION

On Figure 1 we can see a sketch of the volcanic tunnel as well as the geodynamic station located inside the tunnel. We must really differenciate three modules in this laboratory. The main module is, Figure 1(a), the one located in the interior of the tunnel, at around 1 km from the coastal line and at about 5 km, from the volcano that gives origin to the tunnel. In this module are most of the sensors presently installed which can be seen in Table 1 (Fernández et al., 1990(a)).

Another observational module is placed in the intersection of the tunnel with the ocean, Figure 1(b), where a lake of incredible transparence is formed. This lake being directly connected with the ocean shows the corresponding tides, although as it is normal, with the difference originated by the form, dimensions and oceanic connection of the tunnel; we have installed sensors in this module to continuosly register the sea level as well as the air temperature, presure and humidity.

Finnally, the third module, Figure 1(c), is located in the so named *Casa de los Volcanes*, a cultural, scientific and turistic center that the Cabildo de Lanzarote is finishing to make in the existing buildings in the place known as *Jameos del Agua* in the lake area. In this third module is located the central computer, which is directly linked with the observational modules and allows to collect all the information registered in such modules. We have foreseen the connection via telephonic modem between this computer and another one located in the offices of the I.A.G. in Madrid.

INSTRUMENTS

On Table 1 we relate the main characterics of the instruments working in the geodynamic station. A data acquisition system designed in cooperation with the company Geonica S.A. (Fernández et al., 1989) allows a data collection, for the 16 sensors connected, every second; providing a rate every ten minutes, and this is the datum which goes to the memory system.

RESULTS

Apart from the results, periodically or continuosly made in the laboratory and near surroundings, of temperature and high accuracy measurements from wich we are informing in a different work published as well in this volume (J. Fernández et al., 1990(b)), the main results obtained up to the moment are resumed in the following sections:

1°) Gravimeters: The analysis of the series of more than 3 years (R. Vieira et al., 1988(d); R. Vieira et al., 1988(e); R. Vieira et al., 1989(b)) obtained with the LaCoste Romberg n° 434 gravimeter with a feedback system incorporated (M.V. Ruymbeke, 1985) are shown on Table 2. We must point out the high quality of these results reflected by the low rate of quadratic errors in diurnal and semi-diurnal bands.

The strong oceanic effect observed in semi-diurnal frecuencies must be lately studied, as the station offers peculiarities that make it very interesting (C. Toro, 1989). We can advance as an hypothesis that the laboratory located in the ground gained to the ocean in the eruption of the *La Corona* volcano, which we suppose ocurred two o three thousand years ago (T. Bravo, 1964; F. Macau, 1965), is floating, or even better, sustained over a sea of lavas of a very low density and that the ocean itself enters beneath this laval surface, known in volcanological terms as "malpaís", up till it reaches the old coastal line located at more than 3 km in the direction of the volcano itself, Figure 2.

Because of the tidal effect, the sea level suffers variations of more than one and a half meters; these level fluctuations are as well verified under this surface of lavas giving place to several phenomena such as the strong oceanic effect observed in the analysis of the gravimetric records. Likewise we have observed that the sea level oscillations registered in the mareograph located in the module number two of the laboratory, with periods between the range of 10 to 12 minutes whose cause we are investigating, are perfectly registered in both, the gravimeters and the instruments installed in the laboratory, and very specially in the two components of the long base clinometers (WT 1 and WT 2) and in the three components of the vertical pendulum. In agreement with this hypothesis the thermal variations of the semi-diurnal frecuencies and the humidity variations registered in the *Cueva* would be as well related with these phreatic level fluctuations induced by the oceanic tide.

2°) A vertical pendulum of 6 m length was installed in the station in 1989. This pendulum allows to register not only tilts in the directions north/south and east/west but the vertical deflections; afterwards, on February 1990, two clinometers of a long base, of 24.3 and 12 meters, were installed (M. Van Ruymbeke et al., 1990) to measure tilts between its ends which were oriented according to the tunnel direction and in a perpendicular way to such direction. The output of these instruments remains registered in a continuous way over an analogical support and with a periodicity of ten minutes over digital support. These observations have allow us to register phenomena which may have a great scientific interest.

Taking on account the high accuracy of these instruments, the clinometric tide can be clearly seen in the records, obviously influenced by the strong oceanic effect which we have already commented. The two instruments designed, built and installed in collaboration with the E.C.G.S. and the O.R.B. offer, in the period of common register, clear samples of absolute coincidences pointing out the two of them distorsion phenomena, always of small amplitude, which have been taken place in the area of the tunnel where they are located.

From the geodynamic point of view, there are some evidences of a very special interest in the records obtaines up to this moment. In this way, we could observe that important tilts have taken place and have been registered in both instruments in those days previous to the two seismic perceived, which have taken place during 1990 in the area of the Canary Islands, both of them between the islands of Tenerife and Gran Canaria on January the 8 and May the 20. Obviusly it is not a very significative sample, but we beleave it is a interesting to point it out specially because it is indicating us something that, if we could confirm it in a future happenings of the same kind, it would be of the greatest importance. On Figure 3 we can see an aspect of the digital register of several sensors, and on Figure 4 the record of the vertical pendulum precisely corresponding to the period of the seism of January the eight.

3°) Finally, in more than three years of continuous sea level record with the mareograh installed in the lake, several phenomena have been detected: period oscillations with a range of some minutes which could be related to other phenomena, may be atmospheric ones. We must point out that these oscillations have been likewise registered in the gravimeters, pendulum and long base clinometers installed in the same tunnel at something less than 1 km distance. The harmonic analysis of the mareographic series can be seen on Table 3. at present we are studing some long period modulations which affect to the amplitude of the main harmonics (C. Toro, 1989) and which possible are from astronomic origin. In the same manner, the desphases existing with respect to the mareograph located in the Arrecife port, at around 15 km distance, are a very clear sample of the peculiar hydrodinamic regime of the volcanic tube, whose connection with the ocean has not been clearly shown by the speleological investigations which have taken place, reaching the last of them up to almost two kilometers without finding a clear comunication with the ocean.

Taking on account our philosophy on what we consider a laboratory of experiences, the installation of new sensors is planned for a near future, as well as the transfer of a gravimeter beloging to the O.R.B. to the south of the island, and more exactly to the National Park of *Timanfaya*, where the most important geothermal anomalies take place (V. Araña et al., 1973; V. Araña et al., 1984), in this way we could investigate the more than probable difference in the answer of the shell to the forces derived from the astronomical potential and obtain interesting conclusions about possible correlations already indicated by some works published (A. L. Yanshin et al., 1986; E. S. Robinson, 1989).

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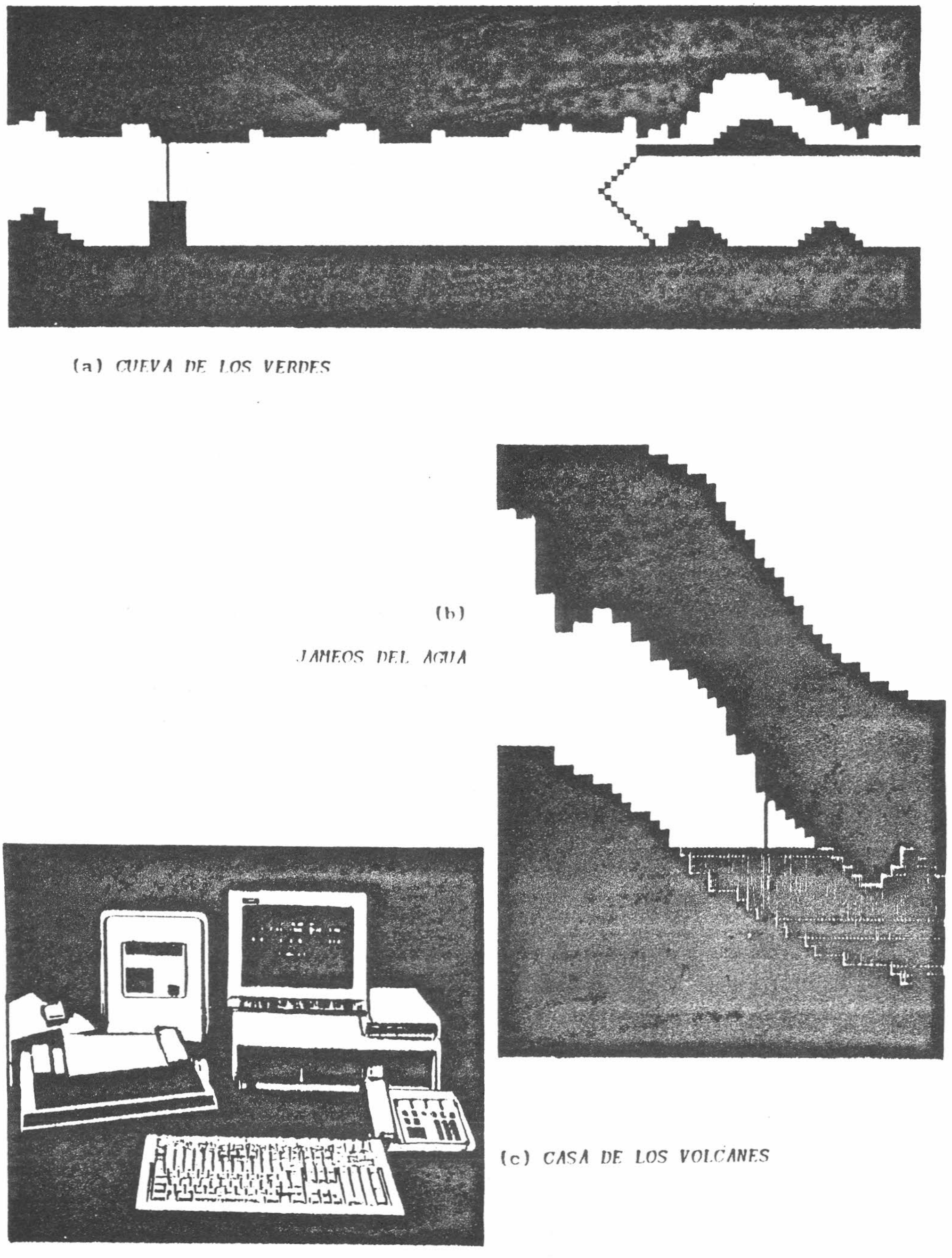

(a) CUEVA DE LOS VERDES

(b)

JAMEOS DEL AGUA

(c) CASA DE LOS VOLCANES

Figure 1

G1 - LACOSTE ROMBERG GRAVIMETER N° 434

G2 - LACOSTE ROMBERG GRAVIMETER N° 336

Ti (i=1,2,3) - HIGH PRECISION THERMOMETERS (0.001 K)

Hr - HUMIDITY SENSOR (%)

Ta - THERMOMETER FOR AMBIENTAL TEMPERATURE (0.01 K)

Pa - ATMOSPHERIC PRESSURE (0.1 mb)

Pv - VERTICAL PENDULUM (6.84 m LENGTH)(SENSIBILITY: 0.696 "/V (E-W); 0.605 "/V (N-S))

WT1 - WATER TUBE N°1 (E-W) (24.3 m LENGTH) (SENSIBILITY: 0.313 "/V)

WT2 - WATER TUBE N°2 (E-W) (8.2 m LENGTH) (SENSIBILITY: 0.8014 "/V)

S.A.D. - DATA ACQUISITION SYSTEM (0.1 mV RESOLUTION)

F.A. - POWER SUPPLY

R.A. - ANALOGIC RECORD SYSTEMS (6 UNITS)

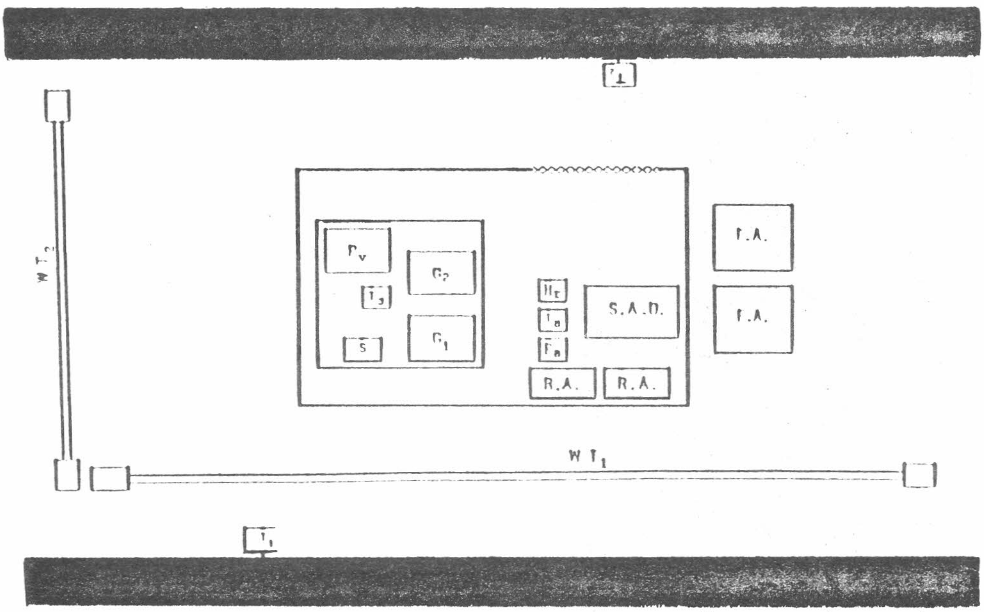

Table 1

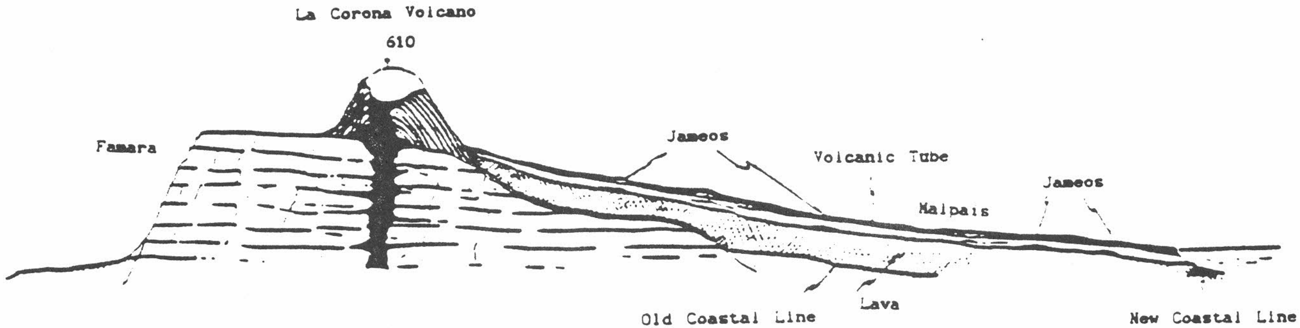

Figure 2 (F.Macau, 1965)

STATION CUEVA DE LOS VERDES VERTICAL COMPONENT SPAIN
29 09 N 13 26 W H 060 M P 40 D 1 KM

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GRAVIMETER: LACOSTE ROMBERG MOD.G N-434 (M-0) (M.VAN RUYMBEKE)
REGISTRATOR: MICROESCRIBE
CALIBRATION: VALLE DE LOS CAIDOS. FUNDAMENTAL STATION
INSTALATION: R.VIEIRA, J.FERNANDEZ
MANTENANCE : O.HERNANDEZ, J.HAVERAN

LEAST SQUARE ANALYSIS / VENEDIKOV FILTERS ON 48 HOURS / PROGRAMMING B. DUCARME
POTENTIAL CARTWRIGHT-TAYLER-EDDEN / COMPLET DEVELOPMENT
COMPUTING CENTER OF UNIVERSIDAD COMPLUTENSE DE MADRID
COMPUTER IBM 4381 PROCESSED ON 90/ 9/25

INERTIAL CORRECTION PROPORTIONAL TO THE SQUARE OF ANGULAR SPEEDS
NORMALISATION FACTOR 0.99203
PHASE LAG O1 0.25 M2 0.50 O1/M2 0.50
INSTRUMENTAL LAG 173.10 MIN.
CORRECTION FOR DIFFERENTIAL ATTENUATION M2/O1 1.00151 /MODEL 2/

434	87 515/87 525	87 528/87 6 3	87 711/871011	871111/871129	8712 3/88 215
434	88 219/88 3 4	88 3 8/88 314	88 317/88 430	88 5 4/88 6 7	88 619/88 723
434	88 727/88 9 9	88 929/8810 5	881013/881015	881022/881022	881027/881220
434	881226/881230	89 1 4/89 1 4	89 110/89 221	89 226/89 4 7	89 411/89 5 1
434	89 5 5/89 517	89 525/89 527	89 530/89 6 1	89 6 7/89 6 9	89 616/89 616
434	89 621/89 7 9	89 714/89 716	89 728/89 813	89 817/89 817	89 822/89 824
434	89 830/89 9 3	89 9 6/891010	891015/891015	891020/891030	8911 4/891122
434	891125/90 1 6	90 111/90 115	90 118/90 3 1	90 3 8/90 316	90 410/90 412
434	90 415/90 429	90 5 4/90 516	90 521/90 523	90 526/90 611	90 617/90 619
434	90 623/90 7 7	90 712/90 712	90 718/90 730		

TIME INTERVAL 1174.0 DAYS 22368 READINGS 48 BLOCKS

WAVE GROUP ARGUMENT		N	WAVE	ESTIMATED AMPL.	R.M.S.	AMPL. FACTOR	R.M.S.	PHASE DIFF.	R.M.S.	RESIDUALS AMPL.	PHASE	MEAN AMPLITUDE
INVERTED READINGS												
115.	11X.	11	SIGMQ1	0.24	0.02	1.2535	0.0796	-0.82	3.64	0.02	-10.9	0.30
124.	126.	10	2Q1	0.85	0.02	1.2736	0.0250	-1.36	1.12	0.08	-14.9	0.99
127.	129.	11	SIGMA1	0.99	0.02	1.2242	0.0206	0.93	0.96	0.05	17.1	1.15
133.	136.	20	Q1	5.96	0.02	1.1775	0.0032	-2.06	0.16	0.23	-67.9	6.94
137.	139.	10	RO1	1.13	0.02	1.1794	0.0170	-0.11	0.82	0.02	-6.5	1.30
143.	145.	16	O1	30.22	0.02	1.1438	0.0006	-1.38	0.03	0.84	-119.9	35.18
146.	149.	10	TAU1	0.34	0.02	0.9707	0.0632	-0.20	3.73	0.07	-178.9	0.27
152.	155.	15	NO1	2.38	0.01	1.1441	0.0065	0.59	0.33	0.04	141.4	3.13
156.	158.	7	KI1	0.44	0.02	1.1021	0.0387	-0.43	2.01	0.02	-171.6	0.51
161.	163.	10	P1	13.78	0.02	1.1209	0.0015	0.34	0.08	0.41	168.5	13.66
164.	164.	3	S1	0.19	0.03	0.6376	0.0707	3.14	8.32	0.15	176.1	0.13
165.	168.	20	K1	41.26	0.02	1.1103	0.0004	0.46	0.02	1.07	161.9	45.48
172.	174.	8	TETA1	0.45	0.02	1.1224	0.0396	1.92	2.02	0.02	136.6	0.51
175.	177.	14	J1	2.40	0.02	1.1534	0.0077	0.79	0.38	0.04	117.0	2.74
181.	183.	7	SO1	0.36	0.02	1.0563	0.0444	0.25	2.41	0.04	177.4	0.44
184.	186.	11	OO1	1.30	0.01	1.1455	0.0073	1.04	0.46	0.03	126.4	2.28
191.	195.	14	NU1	0.24	0.01	1.0221	0.0490	1.88	2.57	0.02	152.5	0.42
INVERTED READINGS												
215.	22X.	12	S2	0.45	0.02	1.0743	0.0376	-6.90	2.01	0.07	-125.9	0.46
233.	236.	10	2N2	1.41	0.02	0.9736	0.0119	-2.29	0.70	0.28	-168.3	1.37
237.	23X.	10	MU2	1.71	0.02	0.9791	0.0099	-3.86	0.57	0.34	-160.2	1.66
243.	245.	13	N2	10.82	0.02	0.9876	0.0015	1.13	0.09	1.90	173.6	10.46
246.	248.	11	NU2	2.08	0.02	1.0005	0.0080	1.25	0.46	0.34	172.2	2.01
252.	258.	26	M2	57.82	0.02	1.0103	0.0003	2.65	0.02	9.04	162.8	55.94
262.	264.	5	LAMB2	0.45	0.02	1.0573	0.0385	2.34	2.08	0.05	157.4	0.43
265.	265.	9	L2	1.71	0.01	1.0539	0.0092	3.53	0.50	0.20	149.1	1.66
267.	272.	5	T2	1.60	0.02	1.0256	0.0099	3.63	0.55	0.24	154.8	1.60
273.	273.	4	S2	28.24	0.02	1.0604	0.0006	4.57	0.03	3.55	140.7	28.29
274.	277.	12	K2	7.62	0.01	1.0514	0.0017	4.37	0.09	1.00	144.3	9.77
282.	285.	15	ETA2	0.43	0.01	1.0506	0.0264	6.42	1.44	0.07	134.7	0.61
292.	295.	11	2K2	0.11	0.01	1.0546	0.0632	4.43	3.42	0.01	143.1	0.25
INVERTED READINGS												
335.	375.	16	M3	1.06	0.01	1.0804	0.0079	2.20	0.42	0.09	25.9	1.04

STANDARD DEVIATION D 1.72 SD 1.48 TD 0.69 MICROGAL
STUDENT FACTOR T(S-95(,N> 915)=1.96

O1/K1 1.0302 1-O1/1-K1 1.3046 M2/O1 0.8832
CENTRAL EPOCH TJJ= 2447516.0

Table 2

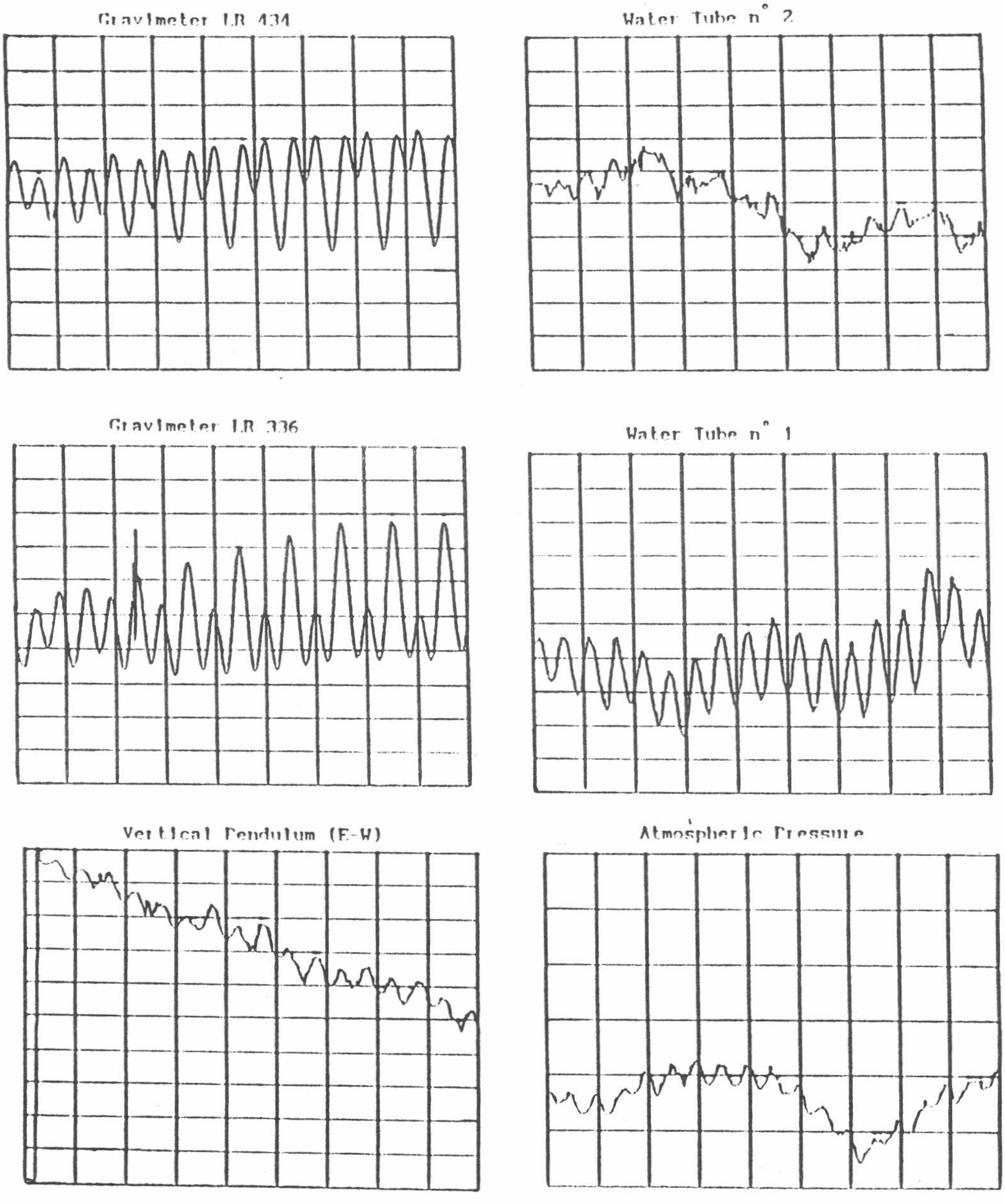
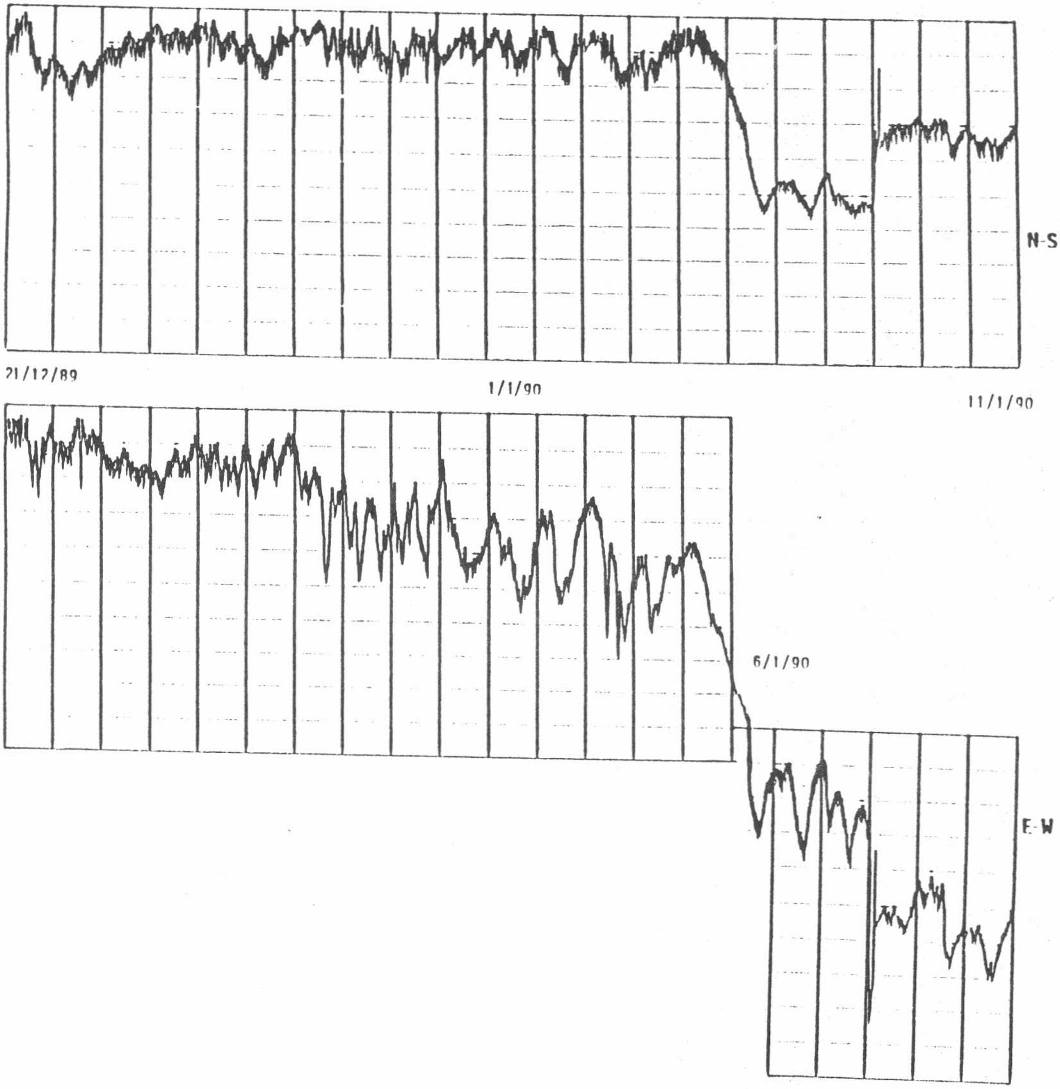

Gravimeter LR 434
Water Tube n° 2
Gravimeter LR 336
Water Tube n° 1
Vertical Pendulum (E-W)
Atmospheric Pressure

Figure 3



VERTICAL PENDULUM PVVRR88 001

GEODINAMIC STATION "CUEVA DE LOS VERDES"

(LANZAROTE, CANARY ISLANDS)

(21-12-89 -- 11-1-90)

Figure 4

OCEAN TIDE
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STATION	JAMEOS DEL AGUA. CASA DE LOS VOLCANES. LANZAROTE.
SITUATION	29 09 N - 13 25 W
ORGANISM	INSTITUTO DE ASTRONOMIA Y GEODESIA (C.S.I.C. - U.C.M.)
MAREOGRAPH	001 - 002 - 522 (SENSORS OF PRESSURE)
REGISTRATOR	OMNISCRIBE
INSTALATION	R.VIEIRA
CALIBRATION	R.VIEIRA
MANTENANCE	J.NAVERAN, O.HERNANDEZ
ANALYSIS	LEAST SQUARE. VENEDIKOV FILTERS ON INTERVALS OF 48 HOURS. POTENTIAL CARTWRIGHT-TAYLER EDDEN, COMPLETE DEVELOPMENT.
	THE FACTOR OF AMPLITUDE, PHASE AND RESIDUALS ARE COMPUTED WITH RESPECT TO EQUILIBRIUM TIDE
	COMP. CENTER UNIVERSITY MADRID.
	COMPUTER I.B.M. 4381. PROCESSED ON 91/ 1/ 9
TIME INTERVAL	87 712/87 812 87 9 9/8710 7 871012/88 425
	88 612/88 7 1 88 7 6/88 819
TIME INTERVAL	88 823/8810 4 881010/89 416 8912 1/8912 1
	8912 4/90 310 90 313/90 424
TIME INTERVAL	90 427/90 714 90 717/90 721
	1107.0 DAYS 19008 READINGS 12 BLOCKS

WAVE GROUP ARGUMENT.	N	WAVE	ESTIMATED AMPL.	R.M.S.	AMPLITUDE FACTOR	R.M.S.	PHASE DIFF.	R.M.S.	RESIDUALS AMPL.	PHASE
115.-11X.	11	SIGMQ1	0.06	0.03	0.2442	0.1143	-7.17	26.82	0.18	-177.7
124.-126.	10	2Q1	0.38	0.03	0.4593	0.0364	26.07	4.54	0.51	161.0
127.-129.	11	SIGMA1	0.27	0.03	0.2683	0.0278	31.22	6.36	0.78	162.8
133.-136.	20	Q1	1.54	0.03	0.2468	0.0047	66.26	1.09	5.80	165.9
137.-139.	10	RO1	0.30	0.03	0.2566	0.0246	67.28	5.50	1.11	165.3
143.-145.	16	O1	4.48	0.03	0.1373	0.0009	-66.03	0.37	31.09	-172.4
146.-149.	10	TAU1	0.06	0.04	0.1470	0.0892	76.17	34.78	0.42	171.6
152.-155.	15	NO1	0.11	0.02	0.0415	0.0096	1.10	13.28	2.46	180.0
156.-158.	7	KI1	0.08	0.03	0.1582	0.0571	-30.24	20.67	0.43	-174.7
161.-162.	3	PI1	0.04	0.03	0.0471	0.0378	47.35	45.98	0.86	178.0
163.-163.	7	P1	1.56	0.03	0.1030	0.0023	28.55	1.27	13.84	176.9
164.-164.	3	S1	0.80	0.05	2.2146	0.1393	26.95	3.65	0.50	45.9
165.-165.	11	K1	5.37	0.03	0.1171	0.0007	37.52	0.33	41.77	175.5
166.-166.	2	PSI1	0.09	0.03	0.2361	0.0727	69.92	22.51	0.35	166.4
167.-168.	7	PHI1	0.12	0.03	0.1875	0.0532	55.57	16.26	0.59	170.2
172.-174.	8	TETA1	0.07	0.03	0.1512	0.0584	79.21	22.13	0.48	171.3
175.-177.	14	J1	0.18	0.03	0.0715	0.0112	-57.81	8.95	2.47	-176.4
181.-183.	7	SO1	0.05	0.03	0.1104	0.0645	-49.95	33.46	0.40	-174.8
184.-186.	11	OO1	0.12	0.02	0.0879	0.0137	10.22	8.92	1.28	-179.0
191.-195.	14	NU1	0.01	0.02	0.0434	0.0706	-20.05	93.18	0.26	-179.1
215.-22X.	19	EPS2	0.48	0.05	0.9171	0.0933	-37.62	5.83	0.33	-116.0
233.-236.	10	2N2	1.93	0.05	1.0709	0.0301	-2.62	1.61	0.15	-35.0
237.-23X.	10	MU2	2.30	0.05	1.0605	0.0246	-15.94	1.33	0.63	-86.1
243.-245.	13	N2	13.70	0.05	1.0082	0.0039	11.80	0.22	2.81	93.5
246.-248.	11	NU2	2.58	0.05	1.0019	0.0205	11.55	1.17	0.52	95.2
252.-258.	26	M2	65.14	0.05	0.9181	0.0007	24.32	0.04	29.23	113.4
262.-264.	5	LAMB2	0.36	0.05	0.6970	0.0972	13.62	7.99	0.19	152.9
265.-265.	9	L2	1.52	0.05	0.7598	0.0241	47.68	1.82	1.49	131.0
267.-272.	5	T2	1.41	0.05	0.7272	0.0253	49.64	1.99	1.48	133.7
273.-273.	4	S2	24.06	0.05	0.7288	0.0015	47.41	0.12	24.36	133.4
274.-277.	12	K2	6.79	0.04	0.7562	0.0042	43.85	0.32	6.23	131.0
282.-285.	15	ETA2	0.35	0.03	0.6825	0.0667	60.74	5.54	0.45	137.8
292.-295.	11	2K2	0.06	0.02	0.4882	0.1563	-87.00	18.33	0.14	-153.4
335.-347.	5	MO3	0.15	0.01	0.6639	0.0622	-86.73	5.38	0.26	-145.4
353.-375.	11	M3	0.22	0.01	0.3562	0.0175	-12.14	2.80	0.55	-170.0

STANDAR DEVIATION D 0.29 SD 0.43 TD 0.11 0.1 MM
FACTOR OF STUDENT T(S-95(,M> 772)=1.96
O1/K1 1.1730 T O1/T K1 0.9771 M2/O1 6.6850
CENTRAL EPOCH TJJ= 2447541.0

Table 3